OPTIMIZATION OF MOLDING PARAMETER EFFECT TO WARPAGE AND SHRINKAGE BASED ON PLASTIC FLOW SIMULATION SOFTWARE: HAND PHONE CASING

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A report submitted in partial fulfilment of
The requirements for the award of the degree of
Bachelor of Mechanical Engineering with Manufacturing

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

DECEMBER 2010

UNIVERSITI MALAYSIA PAHANG
FACULTY OF MECHANICAL ENGINEERING

We certify that the project entitled "Optimization of Molding Parameter Effect to Warpage and shrinkage based on Plastic Flow Simulation Software: Hand Phone Casing" is written by Mohd Norhafizi Bin Rohaizat. We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. We herewith recommend that it be accepted in partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

Examiner　　　　　　　　　　　　　　　　　　　　Signature

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

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Date : ....

STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature : ....

Name : MOHD NORHAFIZI BIN ROHAIZAT

ID Number: ME07036

Date : ....

ACKNOWLEDGEMENTS

First of all, thanks to ALLAH SWT for giving me the strength and the chances in completing this first Final Year Project. In preparing this thesis, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts.

In particular, I wish to express my sincere appreciation to my previous thesis supervisor, Mrs Siti Haryani Binti Tomadi for her encouragement, guidance, critics and friendship in order to finish my final year project. I am also very thankful to all lecturers in Faculty of Mechanical Engineering for their guidance, advices and motivation. The credit also goes to all lecturers, tutors, teaching engineers (JP) especially Mr Imran and assistant teaching engineers (PJP), Mr Faizul for helping me. Without their continued support and interest, this thesis would not have been the same as presented here.

I am also indebted to Universiti Malaysia Pahang for funding my degree study. My coursemates should also be recognized for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am grateful to all my family members.

Finally, I would like to thanks my family especially my parent for their constant support, encouragement and understanding during my studies.

ABSTRACT

Injection molding is a manufacturing process for producing part for both thermoplastic and thermosetting plastic material. Objective of this project to determine the parameter effect to the warpage and shrinkage of the handphone casing and to determine the optimization parameter for reduce the warpage and shrinkage. For this project 3D scanner are use to scan the hand phone casing to get the parameter and analyse with MoldFlow simulation software to optimize the effect to warpage and shrinkage. Shrinkage and warpage tendencies in molded parts,are influenced by actions taken in each and all of the manufacturing stages of part design, material selection, tool design, and processing. The mold temperature(MT), packing time (Pt), packing pressure (PP) and cooling time (Ct) in the packing stage are considered as machining parameters. As increase in mold temperature (MT), the shrinkage also increase and as increase in cooling time (Ct), the shrinkage decrease. Other than that, as increase the packing pressure (PP), the shrinkage usually decrease.

ABSTRAK

Pembentukan suntikan adalah proses pembuatan untuk menghasilkan bahagian untuk kedua-dua bahan plastik termoplastik dan termoset. Tujuan projek ini untuk mengetahui pengaruh parameter pada melenting dan penyusutan selongsong telefon bimbit dan juga untuk menentukan parameter yang optimum untuk mengurangkan melenting dan susut. Dalam projek ini, 3D scanner yang digunakan untuk mengimbas solongsong telefon bimbit untuk mendapatkan parameter dan dianalisis dengan perisian simulasi MoldFlow untuk mengoptimumkan kesan untuk melenting dan susut. Susut dan kecenderungan melenting di bahagian dibentuk, dipengaruhi oleh tindakan yang diambil dalam mana-mana dan semua tahap pembuatan desain bahagian, pemilihan material, rekaan alat, dan pemprosesan. Suhu acuan (MT), masa padatan (Pt), tekanan padatan (PP) dan masa pendinginan (Ct) dalam tahap kemasan dianggap sebagai parameter pemesinan. Seperti kenaikan suhu acuan (MT), susut juga meningkat dan peningkatan masa pendinginan (Ct), susut juga menurun. Selain itu, seperti peningkatan tekanan padatan (PP), susut biasanya menurun.

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INTRODUCTION

1.1 Project Background

Injection molding is a very mature technology, but the growth of layer-build, additive, manufacturing technologies has the potential of expanding injection molding into areas not commercially feasible with traditional molds and molding technique. What is missing is the fundamental understanding of how the modifications to the mold material and mold manufacturing process impact both the mold design and the injection molding process. Plastic injection processes comprise plastication, injection, packing, cooling, ejection and process/part quality control applications. These steps are followed for the parts, which are designed to be produced by plastic injection method.

There are many factors affecting warpage and shrinkage. These are mold temperature, melt temperature, packing pressure, packing time, cooling time, injection velocity, injection time, injection pressure, gate location, runner type, etc. The warpage and shrinkage is reduced further by optimizing the six significant process variables: injection time, post fill (cooling plus packing) time, packing time, packing pressure, melt temperature, and coolant temperature. Computer-aided analysis and engineering software are used in order to minimum the warpage. For plastic injection process, one of the commercial computer-aided engineering software is the MoldFlow. In this study, MoldFlow simulation software is used to make the analysis and optimize the parameter effect to the warpage and shrinkage.

1.2 Project Title

Optimization of Molding Parameter Effect to Warpage and shrinkage based on Plastic Flow Simulation Software: Hand Phone Casing

1.3 Objective

1. To define the molding parameter in injection molding of hand phone casing.
2. To determine parameter effect in molding parameter to warpage and shrinkage of hand phone casing.
3. To optimize the molding parameter and minimize the warpage and shrinkage of hand phone casing based on Plastic Flow simulation software.

1.4 Problem Statements

In this project, warpage and shrinkage are depends on so many factors and one of it is the injection molding parameter. The parameter includes mold temperature, melt temperature, injection time, packing pressure, packing time, and so on. 4 parameters were chosen to make the analysis in order to make the optimization of molding parameter and minimize the warpage and shrinkage of hand phone casing. The parameters include mold temperature, melt temperature, injection pressure and cooling time.

The parameters are used to make analysis base on plastic flow simulation software. In this project, MoldFlow Plastic Insight was use to make the analysis on the chosen parameter. The analysis includes warpage and shrinkage in hand phone casing to optimize the parameters that affect the both defect.

1.5 Scope of Project

Obtain the data and all the information for the title to understand this project by do a lot of research that come from many sources such as internet, books, journals, articles and many more. In other to make more understand on this project, the guidance from the supervisor is important. Also, to check the progress is going smoothly by make sure that the data and information that obtain from the source are really useful for this project. Meeting with supervisor is needed in every week until this project is done.

3D scanning is used in this project also referred as 3D digitizing. This device is utilization of a three dimensional data acquisition device to acquire a multitude of X, Y, Z coordinates on the surface of a physical object or object's shape and appearance include points. The scanner then uses these points to form a 3D digital model of the part. This captured data is typically stored as a list of xyz-coordinates in a point cloud file. 3D scanners can be categorized as contact (CMM arms) or non-contact (white light, 3D laser scanners, or stereo-vision based). Some can even capture internal features.

After getting the shape of the object from the 3D scanning, then the data is transferred into CAD software that known as SolidWorks. SolidWorks is software that uses to utilize a parametric feature-based approach to create models and assemblies. Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. The data is transferred into the SolidWorks because to get the parameters of the objects that will use in further analysis.

Plastic Flow simulation software then will be used to make the analysis to the parameter of the object. SolidWorks Flow Simulation is a Computational Fluid Dynamics (CFD) product for SolidWorks users. It is embedded inside SolidWorks and can perform fluid flow and heat transfer analysis for some types of fluids (liquids, gases, Non Newtonian fluids, Compressible liquid. Other than that, it's a sophisticated practice that's gaining popularity. It helps identify a variety of potential problems and improvements for a mold before it gets built. With this software, analysis about this project can be done also get result to optimize the molding parameter and reduce the warpage and shrinkage.

CHAPTER 2

LITERATURE REVIEW

2.1 Introductions

This project title is optimization of molding parameter effect to warpage and shrinkage based on plastic flow simulation software. Optimization means to make something as good as possible. In this case, optimization of molding parameter is to make improvement about the molding parameter that effect to warpage and shrinkage in injection molding.

Plastic injection processes comprise plastication, injection, packing, cooling, ejection and process/part quality control applications. These steps are followed for the parts, which are designed to be produced by plastic injection method. Having initial knowledge about the process that will be undertaken is necessary because of present-day competitive conditions that force us to produce faster and cheaper with a higher quality, such as minimum warpage, sink marks, etc. Computer-aided analysis and engineering software are used in order to meet this necessity.

In plastic injection process, there is one the commercial computer-aided engineering software's is the MoldFlow Plastic Insight. In this study, process parameters such as mold temperature, melt temperature, packing pressure, packing time, cooling time, runner type and gate location are considered as parameter variables in order to minimize the warpage and shrinkage.

2.2 Injection Molding

Injection molding is one of the most common processing methods for thermoplastics. Nowadays one sees a multitude of different types of injection molded products in homes, vehicles, offices and factories. These include combs, syringes, paint brush handles, crash helmets, telephones, soft drink glasses, gearwheels, brief cases, television housings, typewriters—the list is almost endless.

In the injection molding process, a thermoplastic in the form of granules or powder, passes from a feed hopper into a barrel where it is heated until it becomes soft. It is then forced through a nozzle into a relatively cold mold which is clamped tightly closed. After the plastic is cooled and solidified, the article is ejected and the cycle is repeated. The major advantages of the process includes its versatility in molding a wide range of products, the ease with which automation can be introduced, the possibility of high production rates and the manufacture of articles with close tolerances (R.J. Crawford,1989).

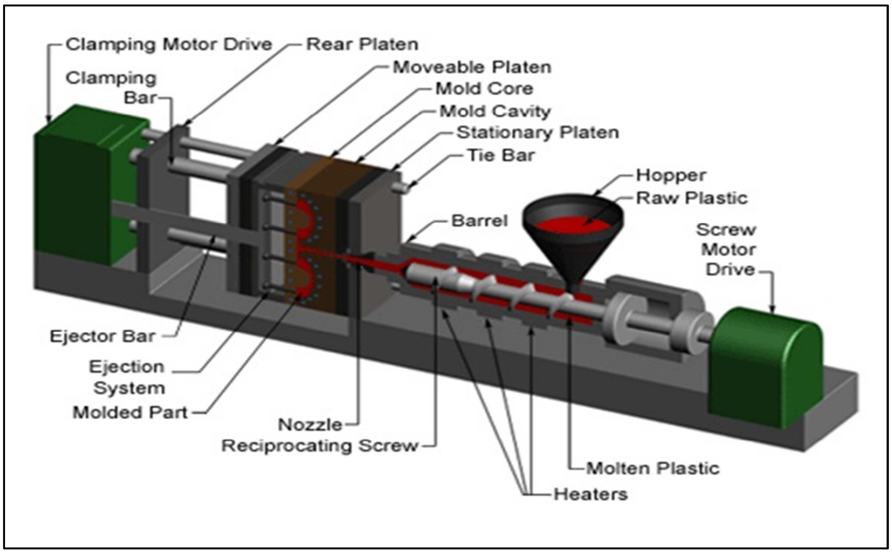

Figure 2.21: The injection major part

Adapted from:

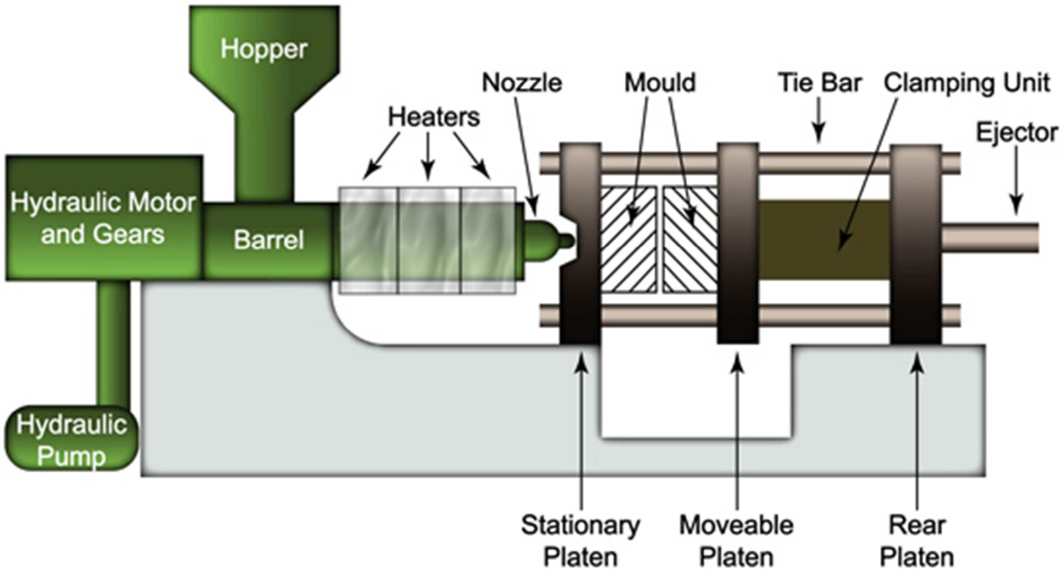

Figure 2.22: The injection molding major part (front view)

Adapted from:

Injection molding is one of the most important polymer processing methods for producing plastic parts (H.T. Paro, C.P. Bosnyak, K. Sehanobish, 1986). Process parameters in addition to molding material and part design are major factors affecting the quality of plastic parts produced by injection molding. Quality of these parts is often associated with warpage. Effects of process parameters on non-uniform shrinkage leading to warpage are investigated from several aspects in literature (A.I. Isayav, Marcel Dekker, 1987).

The injection molding process was first designed in the 1930s and was originally based on metal die casting designs. Injection molding offers many advantages to alternative manufacturing methods, including minimal losses from scrap (since scrap pieces can be melted and recycled), and minimal finishing requirements. Injection molding differs from metal die casting in that molten metal's can simply be poured; plastic resins must be injected with force.

The process uses large injection molding machines, which advance the resins through six major processes to produce everything. Although an injection molding machine is a complex piece of equipment, it consists of two basic elements, the injection unit and the clamping unit.

The process starts with a mold, which is clamped under pressure to accommodate the injection and cooling process. Then, pelletized resins are fed into the machine, followed by the appropriate colorants. The resins then fall into an injection barrel, where they are heated to a melting point, and then injected into the mold through either a screw or ramming device.

Then comes the dwelling phase, in which the molten plastics are contained within the mold, and hydraulic or mechanical pressure is applied to make sure all of the cavities within the mold are filled. The plastics are then allowed to cool within the mold, which is then opened by separating the two halves of the mold. In the final step, the plastic part is ejected from the mold with ejecting pins. The completed part may contain extraneous bits called runners, which are trimmed off and recycled. The entire process is cyclical, with cycle times ranging from between ten and 100 seconds, depending on the required cooling time.

The injection molding process requires some complex calculations. Every different type of resin has a shrinkage value that must be factored in, and the mold must compensate for it. If this value is not precisely determined, the final product will be incorrectly sized or may contain flaws. Typically, this is compensated for by first filling the mold with resin, holding it under pressure, and then adding more resin to compensate for contraction. Other complications may include burned parts resulting from the melt temperature being set too high, warpage resulting from an uneven surface temperature, or incomplete filling due to a too slow of an injection stroke.

2.3 Warpage

Warpage is a distortion where the surfaces of the molded part do not follow the intended shape of the design. Part warpage results from molded-in residual stresses, which, in turn, is caused by differential shrinkage of material in the molded part. If the shrinkage throughout the part is uniform, the molding will not deform or warp, it simply becomes smaller. However, achieving low and uniform shrinkage is a complicated task due to the presence and interaction of many factors such as molecular and fiber orientations, mold cooling, part and mold designs, and process conditions (Kurtaran, H. Kurtaran, B. Ozcelik, T. Erzurumlu, 2005 ; Dong, B.B. Dong, C.Y. Shen, C.T. Liu, 2005).

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Warpage in molded parts results from differential shrinkage. Variation in shrinkage can be caused by molecular and fiber orientation, temperature variations within the molded part, and by variable packing, such as over-packing at gates and under-packing at remote locations, or different pressure levels as material solidifies across the part thickness.

Thicker part sections have limited cooling available and cool more slowly than their thinner or better cooled counterparts. Ribs, bosses, corners, differential mold temperatures, etc., all contribute to variations in cooling time and rate of cooling. In the mold, a part develops a differential temperature profile. When the part is ejected, the thicker sections are still cooling while thinner sections may have reached their final temperature. As the part cools further the thicker areas, which are no longer restrained, contract and possibly cause warpage.

Other causes:

- Warping can also be caused due to non-uniform mold temperatures or cooling rates.
- Non-uniform packing or pressure in the mold.
- Alignment of polymer molecules and fiber reinforcing strands during the mold fill results in preferential properties in the part.
- Molding process conditions--too high an injection pressure or temperature or improper temperature and cooling of the mold cavity.

2.4 Shrinkage

The shrinkage of molded plastic parts can be as much as 20 percent by volume, when measured at the processing temperature and the ambient temperature. Crystalline and semi-crystalline materials are particularly prone to thermal shrinkage; amorphous materials tend to shrink less. When crystalline materials are cooled below their transition temperature, the molecules arrange themselves in a more orderly way, forming crystallites. On the other hand, the microstructure of amorphous materials does not change with the phase change. This difference leads to crystalline and semi-crystalline materials having a greater difference in specific volume ($\Delta \upsilon$) between their melt phase and solid (crystalline) phase. This is illustrated in Figure 2.41 below. Cooling rate also affects the fast-cooling pvT behavior of crystalline and semi-crystalline materials (Kurtaran , H. Kurtaran, B. Ozcelik, T. Erzurumlu, 2005; Dong, B.B. Dong, C.Y. Shen, C.T. Liu, 2005).

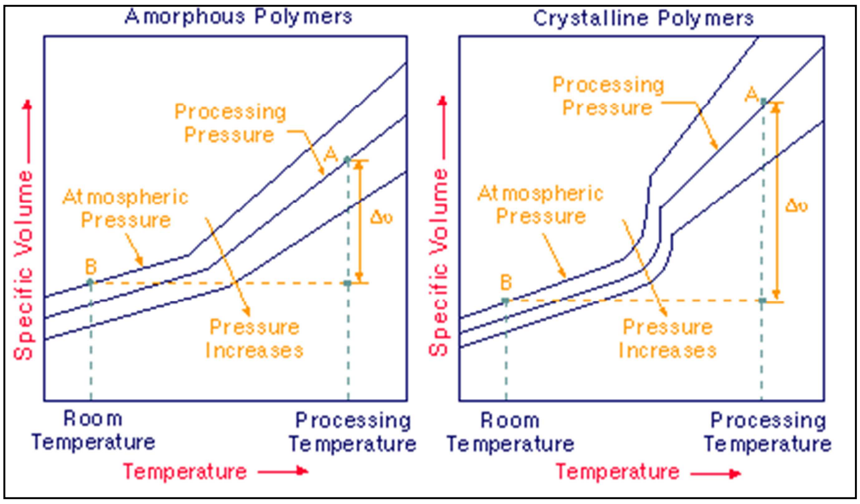

FIGURE 2.41: The pvT curves for amorphous and crystalline polymers and the specific volume variation ($\Delta \upsilon$) between the processing state (point A) and the state at room temperature and atmospheric pressure (point B). Note that the specific volume decreases as the pressure increases.

Adapted from:

Causes of excessive part shrinkage Excessive shrinkage, beyond the acceptable level, can be caused by the following factors. The relationship of shrinkage to several processing parameters and part thickness is schematically plotted in Figure 2.

- low injection pressure
- short pack-hold time or cooling time
- high melt temperature
- high mold temperature
- Low holding pressure.

Problems caused by part shrinkage Uncompensated volumetric contraction leads to either sink marks or voids in the molding interior. Controlling part shrinkage is important in part, mold, and process designs, particularly in applications requiring tight tolerances. Shrinkage that leads to sink marks or voids can be reduced or eliminated by packing the